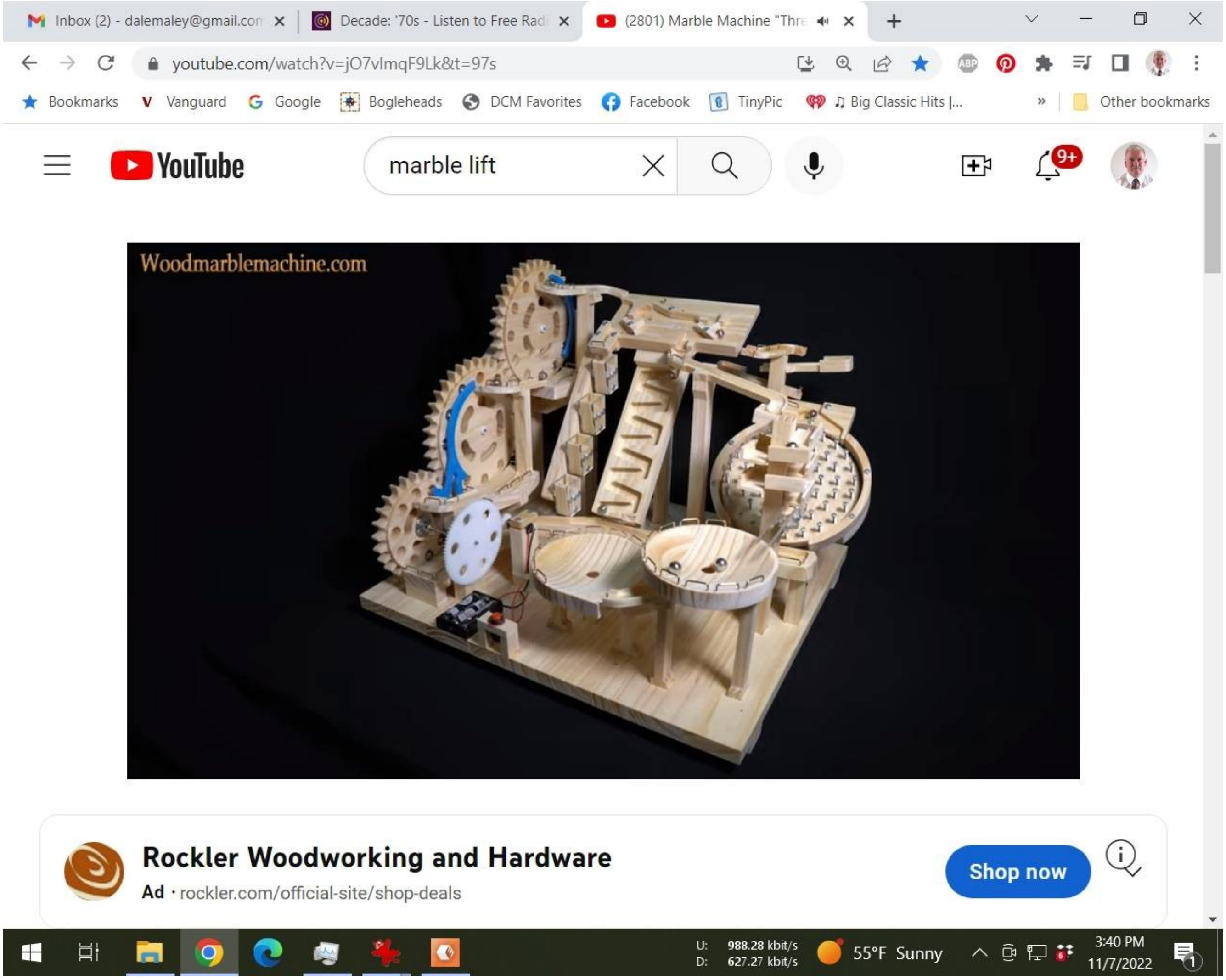
Project to Design and Build a Marble Model that Uses 3 Large Wood Wheels to Raise the Marbles

I have used several methods to lift marbles so they can descend in various fashions. These methods include two 4-bar linkages and the Marble Pump. One method I have not tried, is where you have holes in a rotating wheel, and the wheel lifts the marbles.

Here is an example from a YouTube video.



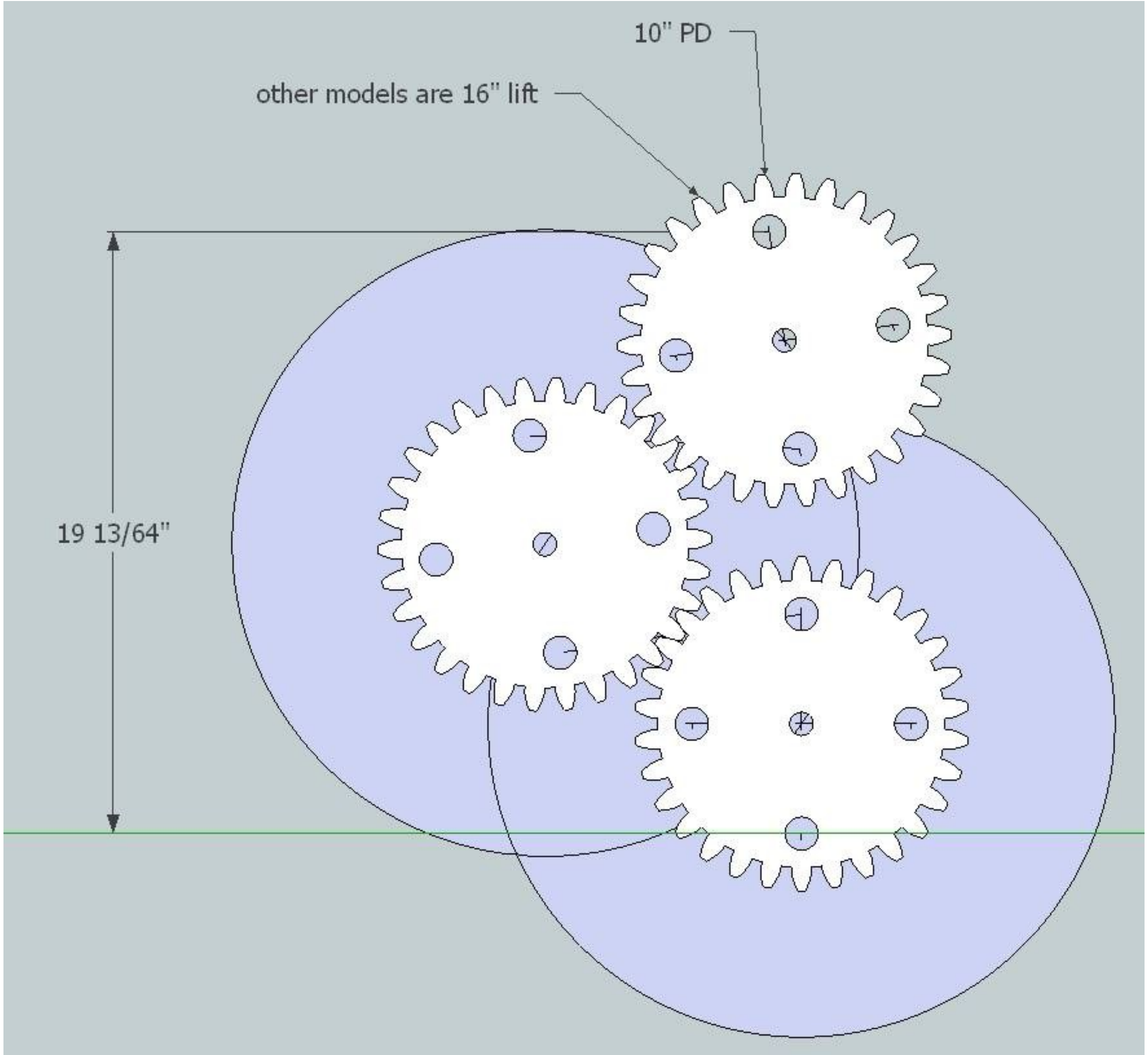
Gear Form Generator

I am using the free GearDXT.exe program to make the gear outline in DXF, then I import it into Sketchup.

Sketchup

From my experience on other marble lift models, I want about 16” of lift.

In Sketchup, I first tried 3 wheels, each with a 10” pitch diameter. I am going to use 1” diameter marbles, so the holes in the wheels will be slightly bigger at 1-1/16” diameter.



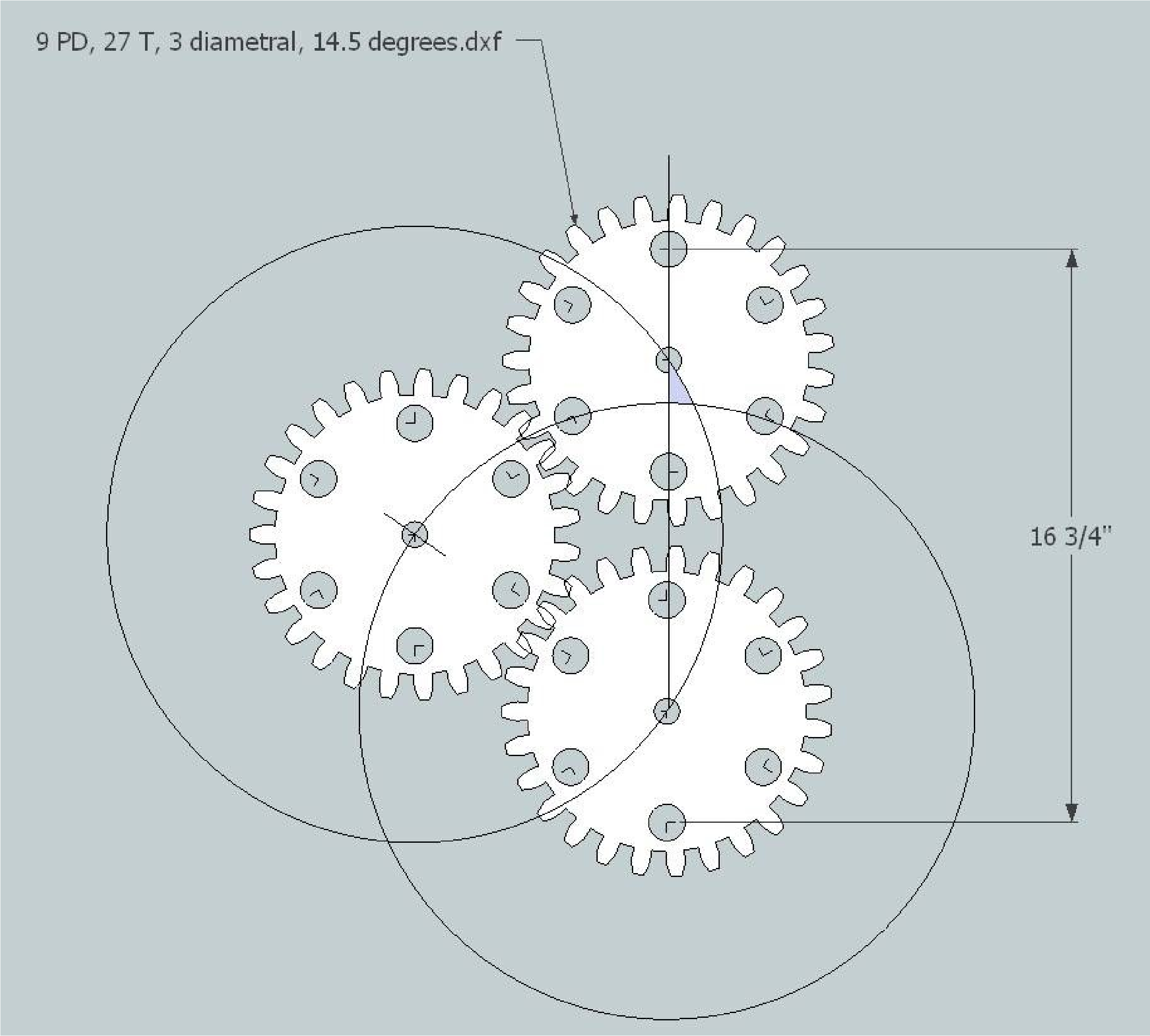
The marbles enter the lowest gear, at the bottom. The crank is on the back side and it will go CW, so in this view the gear moves CCW. The marbles move to the top hole location, then will fall down to the

lowest position on the middle gear. They go from bottom to top on the middle gear, then descend into the lowest hole on the top gear, and it takes it to the top. I got about 19" of fall, more than the 16" I wanted.

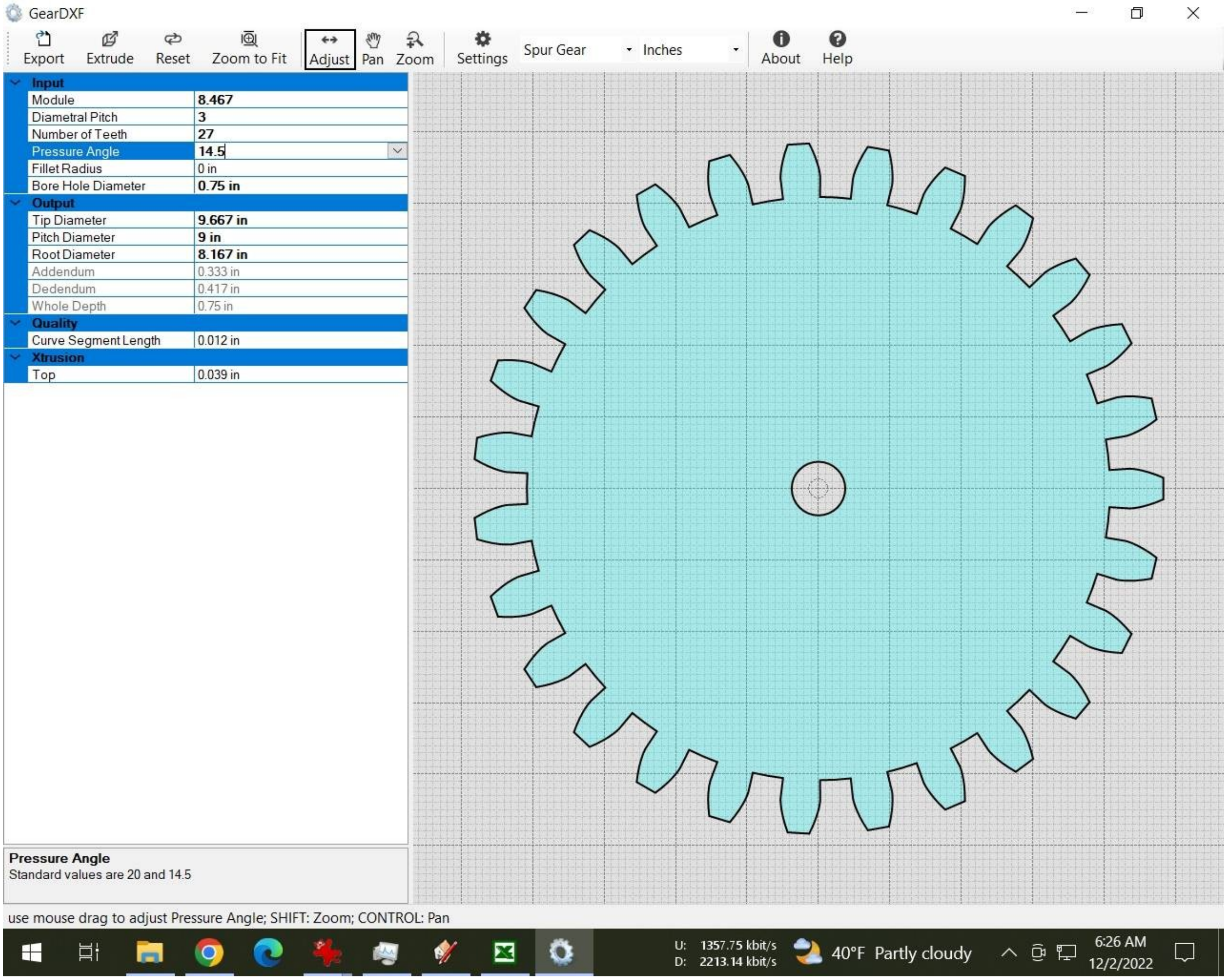
I next tried three gears with each having an 8" pitch diameter.........and I only got 14" of lift, below my 16" target.

Then I mixed two 8's and a 10" pitch diameter.........and got the same 14" of lift.

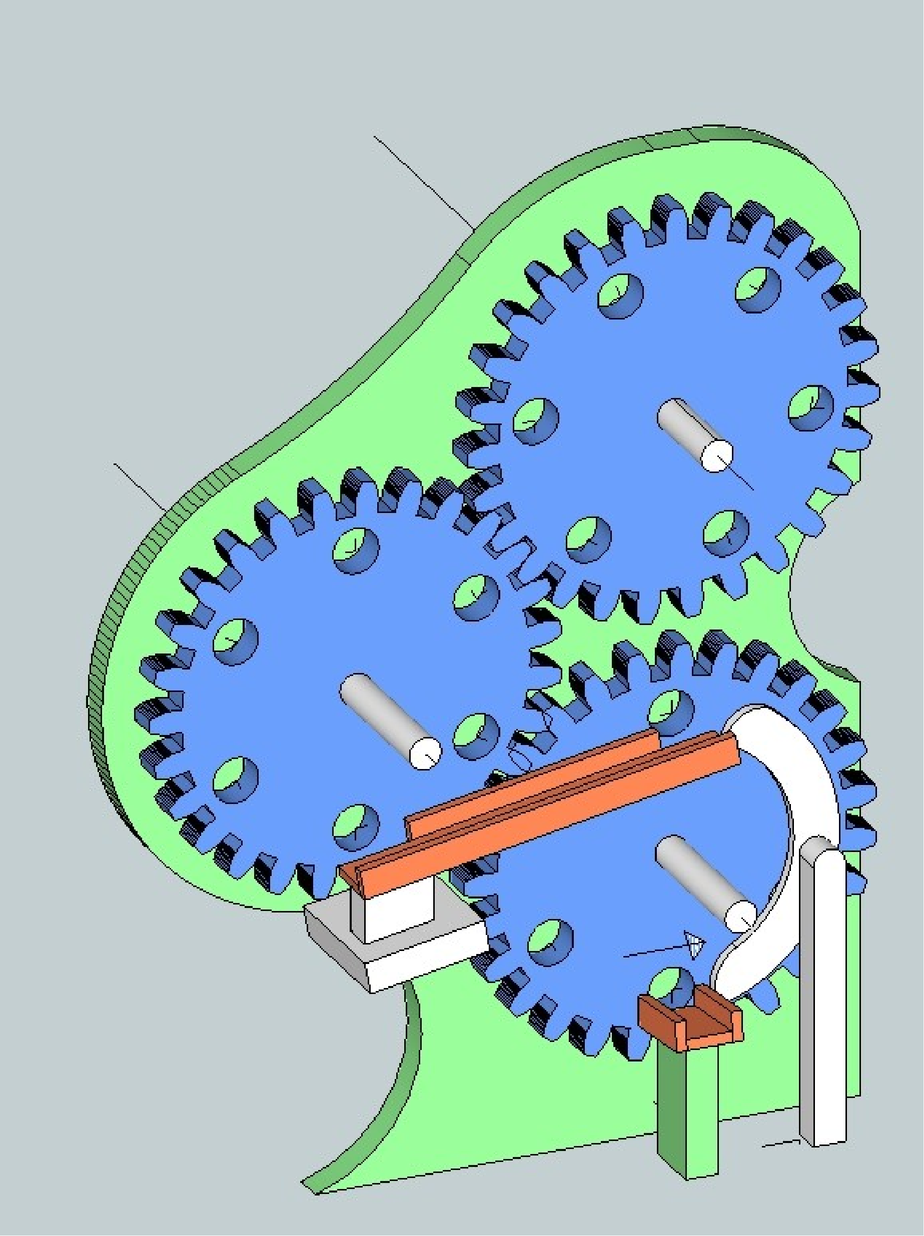
What finally worked was three gears all with 9" pitch diameters.



Big Gear Design from GearDXF Program


GearDXF
Export
Extrude
Reset
Zoom to Fit
Adjust
Pan
Zoom
Settings
Spur Gear
Inches
About
Help
Input
Module 8.467
Diametral Pitch 3
Number of Teeth 27
Pressure Angle 14.5
Fillet Radius 0 in
Bore Hole Diameter 0.75 in
Output
Tip Diameter 9.667 in
Pitch Diameter 9 in
Root Diameter 8.167 in
Addendum 0.333 in
Dedendum 0.417 in
Whole Depth 0.75 in
Quality
Curve Segment Length 0.012 in
Xtrusion
Top 0.039 in
Pressure Angle
Standard values are 20 and 14.5
use mouse drag to adjust Pressure Angle; SHIFT: Zoom; CONTROL: Pan
U: 1357.75 kbit/s
D: 2213.14 kbit/s
40°F Partly cloudy
6:26 AM
12/2/2022

Starting Detailed Design with 3 gears each with 9" PD



Prototype Testing

I should build the lower gear, and the back panel, to test out the design.

I think you drill the holes in the gear at an angle, maybe 6 degrees, so the marble enters at the bottom, but wants to exit at the top.

Since kids can crank up to 100 RPM, I do not want the maximum number of holes in each wheel, because that will be too fast of rate of marbles. I will try 6 holes per wheel.

This should be a fun model to play with :)

Drilling Marble Holes at 6 Degrees

I think I will make a fixture to hold the gear with a shim on 1 side to raise the gear so I get the same 6 degree angle.

If the gear has a 9 inch PD, if I put the shim at 4 inches from the center, how thick does shim need to be?

so horizontal part of triangle would be about 5 from left side to center plus 4 more inches or 9 inches.

we know desired angle is 6 degrees, so shim height should be 9 times Tan of 6 degrees......... = 9 times 0.10510423526 = .95 inches

Different Gear Making Process

1. glue up 2 oak boards to give blank
2. band saw slightly larger than gear OD
3. mark center at same time
4. attach blank to lathe faceplate
5. turn OD of gear
6. put 3/4" bit in tailstock of lathe, drill most of the way through on lathe
7. remove from lathe, hand electric drill what is left
8. glue on Sketchup printout
9. scroll saw the gear teeth

hopefully this will minimize run-out in both directions on the gear!

Hole Size in the gears for the marbles

I am going to use 1" diameter marbles.

I normally use my special 1-1/16" diameter Forstner bit to make holes for these marbles.

I got to thinking about it, and 1/16" on the diameter is not much tolerance to allow the marbles to enter the holes in the gears.

I went back to a couple of Youtube videos that used this concept, and they have plenty of clearance in the holes for the marbles to enter.

So, maybe I should go up to 1-1/4" diameter Forstner bit for these holes instead of 1-1/16 diameter?

My drilling fixture

On the drilling angle, I ended up with a 1" high shim over a run of 9 inches, which is about 7 degree angle. Most marble stuff needs a minimum of 3 degrees, so 7 should make marbles load and unload quickly.

I also chose to go with 1.25" holes, to give some tolerance for the marbles to enter the gear.

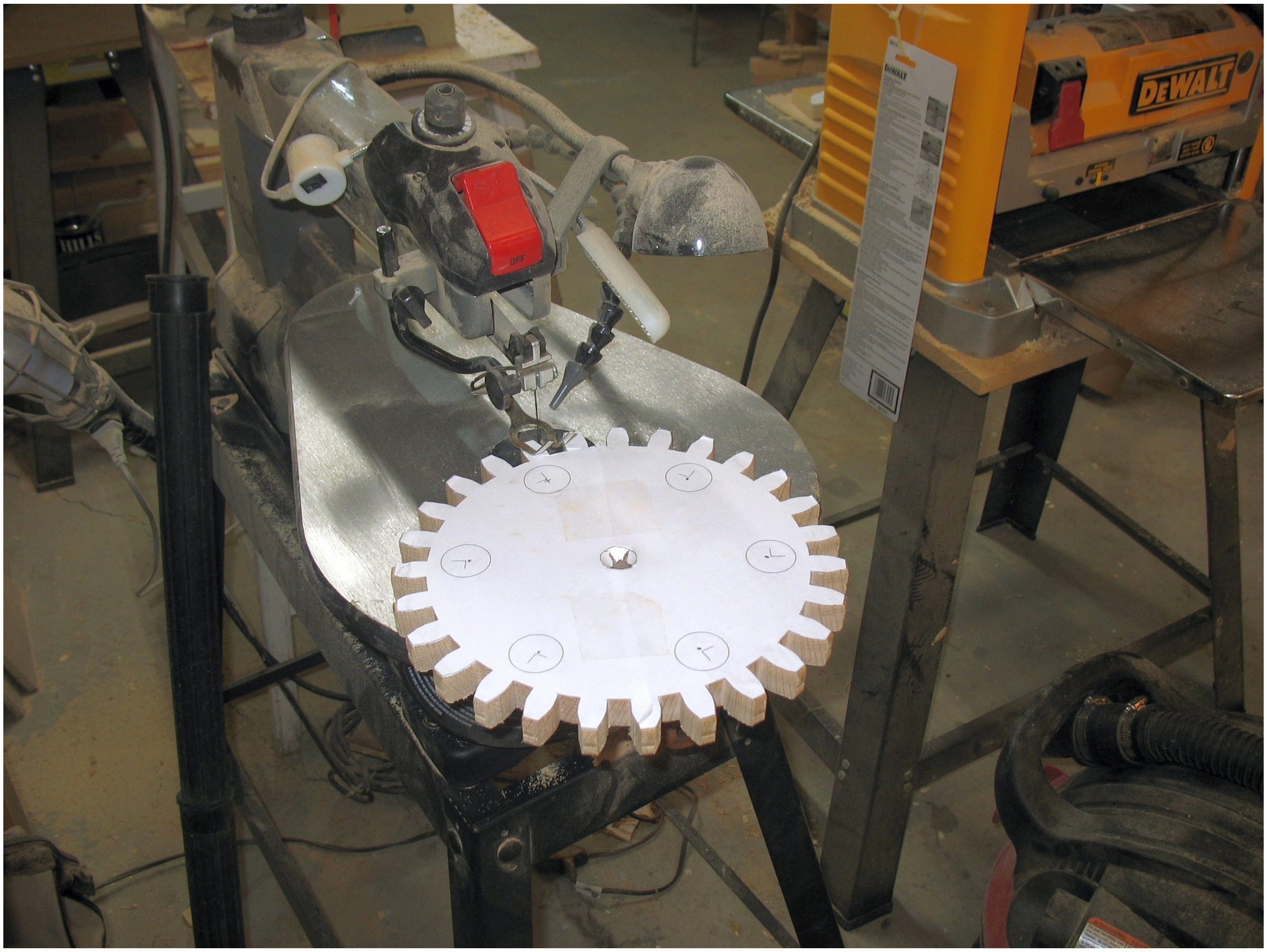
Making 1st gear

1. Glued up 3 pieces to get red oak blank
2. Bandsawed to 10 inch OD, note this max OD that will fit in my 1939 Montgomery Wards wood lathe
3. Mounted on my biggest faceplate with 4 wood screws
4. Turned OD to get as close as I could to Gear OD of 9-5/8" roughly
5. Mounted 3/4" Forstner bit in tailstock and drilled shaft hole almost thru. Quit because I did not want bit to hit steel faceplate, finished
   hole on drill press. I could not really check for runout on the lathe, because piece won't fit with 3-jaw chuck on, not much
   run-out on 3/4 dowel held in vise.
6. Glued on sketchup paper pattern getting outside on OD of gear as best I could
7. Use big bandsaw with 1/8" blade to cut sides of 27 teeth, then scroll saw to cut root line
8. Put in fixture, drill 6 holes, 1-1/4" diameter
9. use wet rag to remove paper and glue, dry in oven

Turning Gear OD on the Lathe

Multipurpose Copy Paper

Cutting Gear Teeth on Scroll Saw

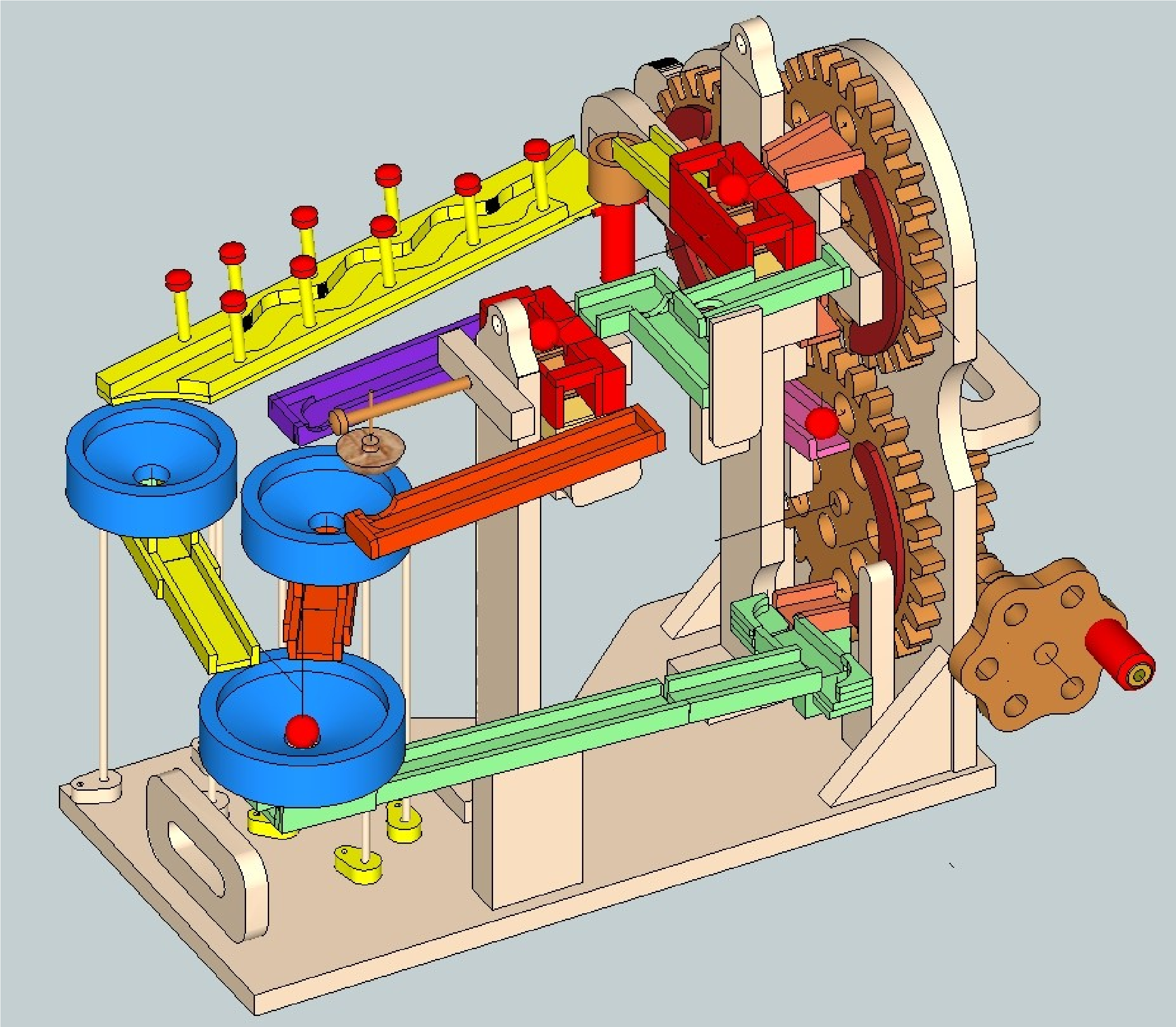


Trial & Error Required

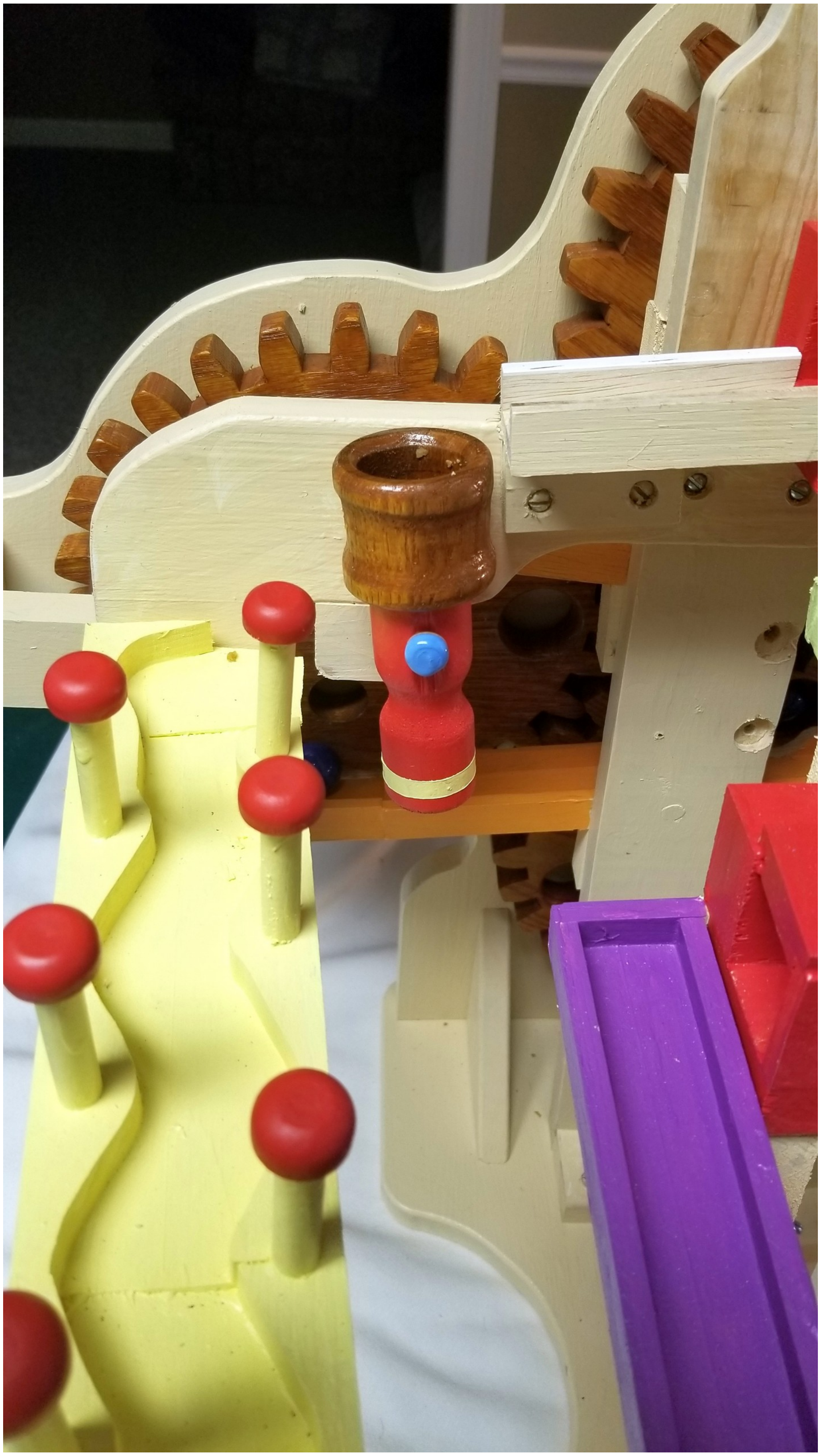
Once I got the 3 big gears mounted on the big vertical board where they could rotate, a lot of trial & error design steps were required to come up with the load/unload chutes and the curved pieces to keep the marbles from falling out of the oak big wheels.

Once I got the load/unload and curved pieces working ok, it was straight forward to add the divider blocks, chutes, bowls.

Sketchup



Finished Design Photos



August 14, 2024 Modifications

When the grandkids played with the model, after it had been setting for many months in my basement, marbles started falling out because the flipper stuck in the unload position.

I decided to try to fix this problem.

I think there were a couple of root causes of why the flipper stuck in the unload position:

1. The hole in the flipper for the ¼” dowel should have been a little bigger diameter.

2. The top of the flipper is too heavy. If it was lighter weight, there would be more gravity force available to return the flipper to the load position.

3. The top of the flipper could rub on the backer board behind it, creating friction.

So I took the following steps:

1. Drilled out the hole a little bit in the middle of the flipper for the ¼” diameter dowel.

2. Drilled about 8 holes, ¼” diameter, in the top of the oak flipper to reduce the weight of the top.

3. Made a 3/8” thick wood washer or shim, to keep the flipper from rubbing on the backer board.

4. Added a top track guide piece to try to make loading a 100% correct happening. Since I spaced the flipper out from the backer board because of the new wood shim, the flipper bucker was not perfectly aligned with the load track any more.

After the modifications, it seemed to work much better and did not stick once.

Other Observations in August 2024

If you crank the hand wheel too fast, you can get marble jams on the initial loading point, and where the marbles load into the middle gear.

Some design options to make this less of an issue:

1. Use a higher gear reduction ratio on the work gear set-up. This would help keep kids from cranking the model too fast, which causes the jams. The marbles don't have time to fall into the hole in the gear.

2. If the holes in the oak gears were a larger diameter, it would give a little more time for the marble to load properly.

The model still works pretty well, so I probably won't make any changes.

February 2025 New Info

The model still jams if you crank it too fast.

I did some testing in December of 2024 or January of 2025, and found my rule of thumb of 100 RPM was the max speed that kids could crank was wrong !!

Using a video of myself, I was able to crank at 202 RPM max !!

Going thru this file from the beginning, I saw no rationale of why I picked the worm gear ratio that I did?

Found an old Excel file about this project:

it works at rate of 6 rev's in 38 sec, which is about 9 RPM

1	9	0.15	6.666667	0.15
6	9	0.15	6.666667	0.9

I was guessing Youtube small marble game was running at 15 RPM, just a little faster than my big marble game

so 100 max crank RPM, and to get 9 RPM on 3 gears……

11.11111

so I need 11 to one speed reduction ratio !!!!!!!!!!!

this is worm gear territory, not spur gears

so if I can run it at 9 RPM and have 6 holes in first gear, then I yield a marble every 1 sec, which is about right

Looks like I thought the max speed the model would run at was 9 RPM……….then I assumed 100 RPM was max kid cranking speed……….. 100/9 = 11.1 worm ratio…….so I picked 12.

so if I wanted 9 model RPM max, and max kid cranking speed was 202 RPM……….

202/9 = 22.4 reduction ratio……..not 12 !!!!!!!!!

Before I make a new worm gear for this model, maybe I should video myself cranking it at what I think max speed should be?

But, some of the 3 big gears are binding at certain spots?? Should probably take apart and shave down teeth to fix any interference problems. Made these gears around November of 2022……..so now they are about 2 years or 25 months old. Gears may have dried out or warped in 2 years? Or the engagement teeth change as you crank and I may not have found these spots when I first built it, because now at different engagement points?

Fixed rough spots

cranked slow with no marbles, and marked teeth that bound with little piece of blue masking tape, then sanded with dremel and 1/8” diameter deburr tool……….then touched up with q-tip and shellac, no stain, matched good.

So I counted 1000 and 1 marble coming off at the top at about 1 per second seems right.

6 holes per big wheel……….so get 6 marbles per rev and 1 rev takes 6 seconds.

1 rev/6 sec x 60 sec/min = 10 RPM

close to the 9 RPM I found earlier as noted above

200 max cranking speed / 9 RPM = 22.22 ratio

200/10 = 20:1 ratio

current ratio is 12:1…….so no wonder I get some jams !!

question is, do I do 20 teeth or 22 teeth?

PD is 4” on mating gear

distance between teeth is 2 pi r divided by number of teeth:

Pi * dia = 12.566

so 20 teeth => 12.556/20 = .6283

so 22 teeth => 12.556/22 = 0.571182

might as well go for 22 teeth.

Angled Spur Gear

tan theta = .5 times distance between teeth/OD

=.5(.571182)/2

=.1427955

angle = 8.12664109 degrees

Making the Worm Gear

I have a piece of 1.5 by 3.5 red oak from menards. I cut off two pieces, each 6 inches long and glued them together. The worm gear length will be 4 inches, but I need 2 inches to use on the faceplate and chuck.

1. Glue up the blank
2. saw off each end to make 3nds 90 degrees to main length
3. Chuck on faceplate in lathe. Put in 2 screws in faceplate to keep blank from rotating
4. Turn RH side down to round (more than final 2" OD)
5. Saw off LH side using the bandsaw
6. Saw LH side in chop saw to make bandsaw cut end at 90 degree, and make final length of 4"
7. chuck in lathe. Drill 3/4" center oil with Forstner bit in tailstock
8. flip part in lathe, drill other end
9. remove from lathe, put in vise, use 3/4" auger bit to connect the holes
10. put blank back in lathe, on a 3/4" diameter steel bolt chucked in lathe
11. turn 1 end down to about 2" OD, flip around and turn the other end, sand

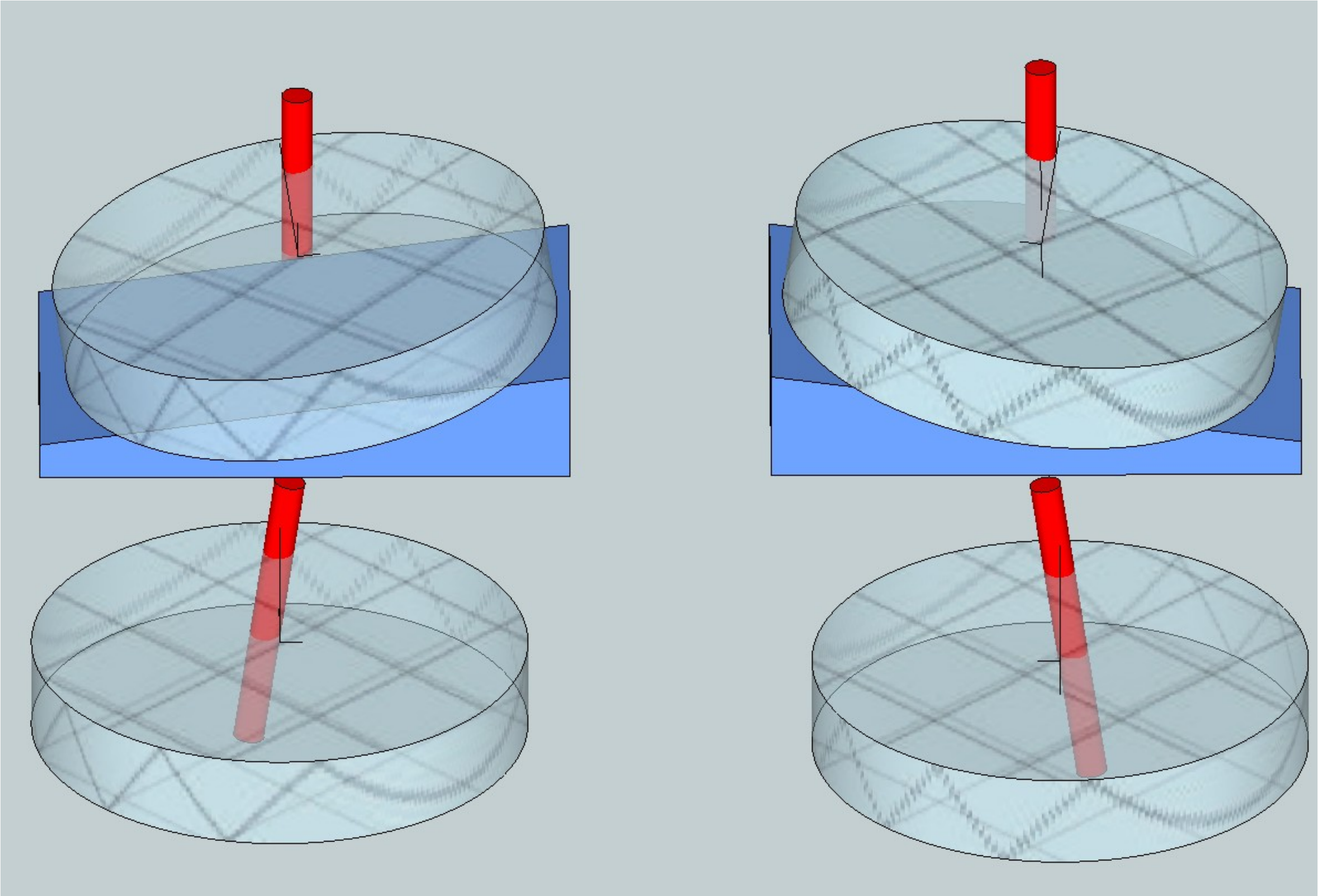
After I removed the part from the lathe, I looked at both ends and was surprised my 3/4" center hole was not perfectly centered !! On the doughnut, one side was maybe 1/16 to less than an 1/8" thicker than the other side??

I think my 6" diameter chuck is too big for my lightweight 1939 Montgomery wards lathe that has just a 5" swing. This causes a lot of vibration, plus no tailstock support on my 3/4" bolt arbor.

OOOOPS

Got new worm gear and mating gear built, put everything together........and darn........I drilled and bandsawed the mating gear the wrong direction !!

Guess I get to make a new spur gear with angled teeth.

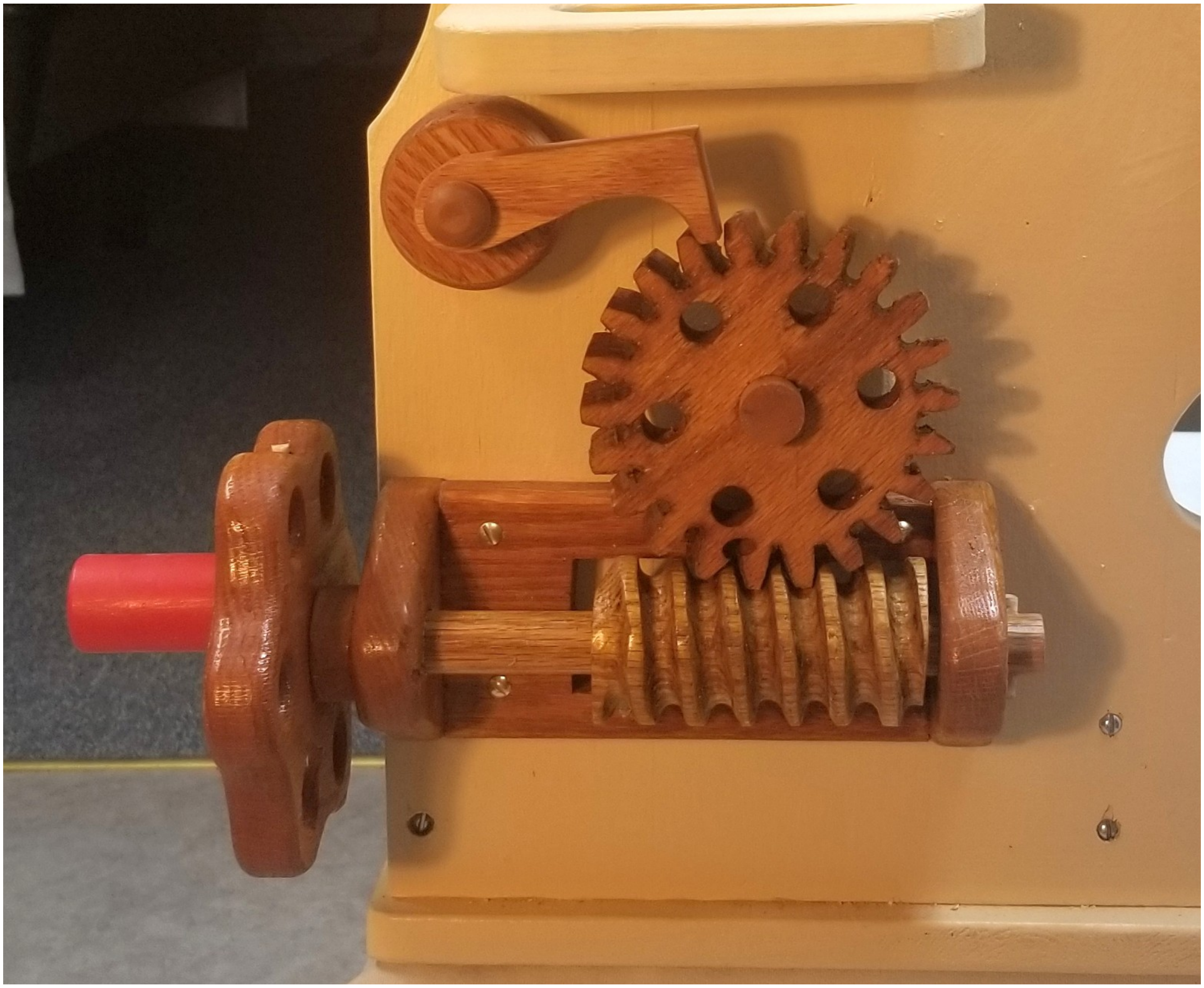


Drill Caught when Drilling 2nd Spur Gear at 8.1 degree Angle

It caught and spun the work piece. I think holding it by hand, I tipped the piece a little of the angled block, and that made it catch. I'm still going to use the piece, even though there is a mark on 1 tooth.

The fat side of the 8.1 degree block goes on the LH side of the work piece for the angle to be right for this worm gear. On the 1st one, I had the fat side on the RH side and it gave the wrong angle.

Finished Project



Youtube Video

https://youtu.be/ysNKvIUTXM4

I tried cranking the new model as fast as I could go, and I was unable to jam it up. Can’t wait for my grand-daughter to test it out and verify she can not jam it !!

Dale C. Maley

Fairbury, Illinois

February 5, 2025